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The Body Area and Size that Chinook, Coho, and Chum Salmon Fry First Form Their Scales

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THE BODY AREA AND SIZE THAT CHINOOK, COHO, AND CHUM
SALMON FRY FIRST FORM THEIR SCALES

by

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ABSTRACT

Bilton, H. T. 1988. The body area and size that chinook, coho, and chum salmon fry first form their scales. Can. Tech. Rep. Fish. Aquat. Sci. 1632: 17 p.

Scales were removed from 25 body positions from each of 100 chinook, 160 coho, and 130 chum fry over the period of March 15 to June 26, 1985. The entire left side of each fry was examined for the presence and distribution of scales. Scale samples were removed from each fish from designated body positions and were subsequently studied under the microscope at a magnification of 250 times. The total number of circuli were counted and recorded. The results indicated that scales began forming on chinook and coho fry when they had reached between 39-41, and 37-40 mm, respectively. There was some suggestion that chum fry formed their scales at 41-42 mm.

In each of the three species, scales first formed just above and below the lateral line. For chinook fry, scales first extended from the mid-point of the dorsal fin posteriorly to the caudal fin. For chum fry, scales first appeared in the area of the preferred scale and extended posteriorly to the caudal fin. Unlike the other two species, the area of scale formation for coho was much more limited, first appearing in a relatively narrow area, at a point mid-way between the operculum and the origin of the dorsal fin. In all three species, scales subsequently formed outwards, towards the back and the belly.

Key words: chinook, coho, chum, salmon fry, scale formation

RÉSUMÉ

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Des écailles ont été prélevées en 25 endroits du corps d'alevins de 100 saumons quinnats, 160 saumons cohos et 130 saumons kétas au cours de la période allant du 15 mars au 26 juin 1985. Tout le côté gauche de chaque alevin a été examiné pour la recherche des écailles dont on a noté la répartition. Des écailles ont ensuite été prélevées, en des points déterminés, et examinées au microscope à un grossissement de 250 fois. Le nombre total d'anneaux a été noté. L'auteur a ainsi déterminé que les écailles apparaissaient chez les alevins de quinnats et de cohos lorsque ceux-ci atteignaient, respectivement, les tailles de 39-41 et 37-40 mm. Selon certains indices, les écailles apparaissaient chez les alevins de kétas lorsqu'ils atteignaient 41-42 mm.

Chez ces trois espèces, les écailles se formaient tout d'abord immédiatement au-dessus et au-dessous de la ligne latérale. Chez les quinnats, les écailles s'étendaient à partir de la partie médiane de la nageoire dorsale en direction postérieure, vers la nageoire caudale. Chez les alevins de kétas, les écailles apparaissaient tout d'abord dans la zone préférentielle et s'étendaient ensuite, postérieurement, vers la nageoire caudale. Au contraire de ces espèces, les écailles des cohos apparaissaient tout d'abord dans une zone relativement limitée, en un point situé à mi-chemin entre l'opercule et l'origine de la nageoire dorsale. Chez les trois espèces, les écailles se développaient ensuite vers l'extérieur, vers le dos et le ventre.

Mots clés: quinnat, coho, kéta, alevin de saumon, formation des écailles

INTRODUCTION

Scale size and number of circuli in relation to the body areas on the fish are known to vary considerably. In a study of three specimens of Atlantic salmon (Salmo salar), Esdaille (1912) found variation in the number of circuli and the lengths of the scales taken from different areas of the same fish. Bilton (1984) examined the variation in scales sampled from different body areas of sockeye salmon yearlings (Oncorhynchus nerka) and found a great variation in the size of scales and in the number of circuli. He concluded that the body area with the largest scales probably provides the most complete record of age and growth of the fish.

These studies point out the importance of standardizing the method of selecting scale samples from fish. Pacific salmon scales are often used to identify origin of stocks (Tanaka *et al.* 1969, French *et al.* 1976). In both studies various measurements were made (e.g. number of circuli, distance and spacing of circuli within various zones on the scales). These measurements had to be precise in order to detect differences among stocks. Hence, standard methods must be used both in the collection of the scales and in the making of measurements of scale characters. Non standardized methods of sampling for scales could influence the precision of measurements of scale characters that would be used to define each stock, and therefore lead to incorrect identification of the stocks and inaccurate estimates of their contribution to the catch.

The present study investigates the extent of such variation in scales of chinook (Oncorhynchus tshawytscha), coho (O. kisutch), and chum (O. keta) salmon. This report includes for each of the three species estimates of: (a) the body area where circuli were first observed to have formed and (b) the size that fish had attained when the first circulus was estimated to have formed.

MATERIALS AND METHODS

DONOR STOCK AND REARING

Three lots, each containing approximately 200 newly hatched fry (from brood stock), of each of the three species of Pacific salmon were placed in individual 45 l tanks. Fry were reared at a mean temperature of 7.6 C (s.d. 0.14) between March 15 and June 6, 1985. During the period of rearing, fry were offered an ad libitum diet of Oregon Moist Pellet (O.M.P.) following normal hatchery procedures.

SAMPLING

Twenty-five scale body positions were designated for sampling (Fig. 1). Seven scale body positions along the first row above the lateral line, and six along the first row below the lateral line. Twelve other scale body positions were selected at different locations above and below the lateral line. The designated scale body positions were as follows:

Position No.	Scale body position
1.	Just below the dorsal ridge and posterior to the head.
2.	Behind the operculum, one row above the lateral line.
3.	Behind the operculum, one row below the lateral line.
4.	Behind and slightly beneath the insertion of the pectoral fin.
5.	Just below the dorsal ridge, and midway between position one and origin of the dorsal fin.
6.	Vertically, below position five and one row above the lateral line.
7.	Vertically, below position six, one row below the lateral line.
8.	Vertically, below position seven, just above the ventral surface.
9.	Below and midway between the origin and insertion of the dorsal fin.
10.	Vertically below position nine, and approximately midway to the lateral line. For chinook row eight, coho row eight, and chum row seven from the lateral line.
11.	Vertically below position ten, one row above the lateral line.
12.	Vertically below position eleven, one row below the lateral line.
13.	Vertically below position twelve, and approximately midway between position twelve and the insertion of the pelvic fin. For chinook row nine, coho row nine, and chum row seven from the lateral line.
14.	Vertically below position thirteen, at origin of the pelvic fin.
15.	Beneath the origin of the adipose fin.
16.	Vertically below position fifteen, one row above the lateral line.
17.	Vertically below position sixteen, one row below the lateral line.
18.	Vertically below position seventeen, at the anal fin.
19.	Vertically below the mid-point between insertion of the adipose fin and caudal peduncle, one row above the lateral line.
20.	Vertically below position nineteen, one row below the lateral line.
21.	Just below dorsal ridge, midway between the insertion of the dorsal fin and position fifteen.
22.	Vertically below position 21, one row above the lateral line.

- 23. Vertically below position 22, one row below the lateral line.
- 24. Vertically below position 23, at the origin of the anal fin.
- P "Preferred Scale", located on the diagonal row from insertion of the dorsal fin and two rows above the lateral line (I.N.P.F.C. 1957).

The fry were examined using a binocular microscope for the presence and distribution of scales, including lateral line scales. Scale samples were removed from each fish from the designated body locations, and mounted onto glass slides. These were subsequently studied at a magnification of 250 times.

At each sampling interval approximately 10 fry were examined. The total number of circuli and the distance from the scale focus to the edge of the scale were counted and measured.

Sampling of each of the three species was as follows:

Coho - samples were collected at 10 to 14 day intervals between March 15 and June 13, 1985, inclusively. One hundred and sixty fry were examined.

Chinook - samples were collected at 10 to 14 day intervals between March 15 and June 13, inclusively. One hundred fry were examined.

Chum - samples were collected at 10 to 14 day intervals between April 17 and June 26, inclusively, one hundred and thirty fry were examined.

Sampling of fry was discontinued when the presence of scales was observed at nearly all body positions. The fork length (mm) of each fry was measured and recorded.

STATISTICAL METHODS

The data were analyzed using simple regression analysis. Linear models were calculated showing the relationship between number of circuli and fish length for each species, and for each of the twenty-five body positions. Other analysis included the calculation of the correlation coefficient. These calculations were based on the mean values for fry length and number of circuli at each sampling interval.

RESULTS

CHINOOK FRY

There was considerable variation in the size of fry when scales first formed at the different body positions (Table 1). Scales first formed in the area just above and below the lateral line, from a point mid-way of the dorsal fin, posteriorly to the caudal peduncle (Fig. 2a), when the fish reached a mean length of from 35.2 to 39.2 mm. Scales subsequently formed just above and below the lateral line from a point mid-way of the dorsal fin anteriorly to behind the operculum (Fig. 2b), when the fish reached a mean length of 41.8 to 46.6 mm. Following this, scales formed dorsally and ventrally, to the lateral line towards the back and the belly (Fig. 2c). The last scales formed were at the back and the belly when fish reached a mean length of 55 and 63 mm.

COHO FRY

As was observed for chinook fry, there was also considerable variation in the size of coho fry when scales first formed among the different body positions (Table 2). Scales first appeared just above the lateral line from a point mid-way between the operculum and the origin of the dorsal fin (bod. pos. 6) when the fish reached a length of 36.6 mm (Fig. 3a). Scales subsequently formed above and below the lateral line from the area of body position 6 anteriorly to the operculum and posteriorly to the caudal peduncle (Fig. 3b), when the fish reached a mean length of from 38.6 to 44.1 mm. Scales then began to form dorsally and ventrally to the lateral line, towards the back and the belly (Fig. 3c). The last scales to form were at the back and the belly, when the fish had reached a mean length ranging between 48.9 and 58.6 mm.

CHUM FRY

In chum fry scales first formed when fish reached a mean length between 41.5 and 42.4 mm (Table 3). Scales were first observed just above and below the lateral line from the position of the preferred scale posteriorly to the caudal peduncle (Fig. 4a). Scales subsequently formed just above and below the lateral line from the preferred scale anteriorly to the operculum (Fig. 4b). Later, scales began to form dorsally and ventrally to the lateral line towards the back and the belly (Fig. 4c). The last scales to form were along the back and the belly, when the fish had reached a mean length ranging between 51.7 and at least 62.9 mm. Scales had not yet formed at body positions 1, 4, 5, and 18 when the experiment was terminated.

COMPARISON OF RELATIONSHIP BETWEEN NUMBER OF CIRCULI AND LENGTH AMONG THE THREE SPECIES

Table 4 shows the mean number of circuli on the scales of the three species when sampled at the same mean size. At all but one body position the coho scales exhibited the highest number of circuli. The only exception was at body position 10, where both the chinook and chum scales exhibited a slightly higher mean number of circuli. Chum fry scales had the lowest number of circuli in relation to their length.

DISCUSSION

Among each of the three species examined, scales first formed along the sides of the fish in a similar manner. In each case, scales first appeared just above and below the lateral line. For chinook fry, scales first extended from the mid-point of the dorsal fin posteriorly to the vicinity of the caudal fin. For chum fry, scales first extended from the area of the preferred scale posteriorly to the caudal peduncle. For coho fry, scales were first observed in a relatively narrow area at a point mid-way between the operculum and the origin of the dorsal fin; and then subsequently extended posteriorly to the vicinity of the caudal fin. For all species, once scales formed along the lateral line, scales formed outwards, both dorsally and ventrally, to the back and to the belly.

Scales began forming on chinook and coho fry at about the same size. However there was evidence that chum fry began forming their scales at a larger size than did either of the two other species.

Comparison of the relationship between number of circuli and length indicated that chum fry had the lowest number of circuli in relation to their size. On the other hand, coho scales exhibited the highest number of circuli in relation to size. The reasons for the differences between the species, particularly, between the chinook and coho are not understood. Both species had been reared under similar environmental conditions, had formed their scales near the same size, and were the same size when they were sampled. Perhaps the reasons for the difference are of a genetic nature. In the case of the chum fry, the lower number of circuli may be related to the fact there was a strong tendency for them to form their scales at a larger size.

It is interesting to note that the "preferred scale", the one that is commonly selected by Pacific salmon scale readers, falls within the area where scales were observed to form first in the chinook and chum fry, but outside the area in the case of the coho fry. This indicates that selection of the "preferred scale" from chinook or chum salmon is not as critical as has been thought up to now. Scales taken near the lateral line between the insertion of the dorsal fin and the caudal peduncle will provide the same

quality of information on the early life history of the fish. On the other hand for coho, it would appear that if maximum information on the early life history of the fish is to be achieved, it is necessary to remove scales from the area just above the lateral line, mid-way between the operculum and the origin of the dorsal fin.

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Table 1. The linear regression formulae for circulus number (Y) on fish length in mm (X), the correlation coefficient (r), and the estimated length of the fish when the first circulus is formed in each of the 25 body positions for chinook salmon fry.

Body pos.	a	b	r	n	Sig.	length at first circulus
2	-11.596	0.270	0.97	12	*	46.6
6	-10.096	0.258	0.98	14	*	43.0
11	-7.379	0.223	0.99	13	*	37.6
P	-7.681	0.235	0.99	15	*	36.9
22	-7.485	0.232	0.99	15	*	36.6
16	-7.105	0.227	0.99	15	*	35.7
19	-5.947	0.188	0.97	13	*	36.9
3	-11.273	0.273	0.97	13	*	45.0
7	-9.328	0.247	0.99	13	*	41.8
12	-8.813	0.250	0.98	14	*	39.2
23	-7.464	0.232	0.99	15	*	36.5
17	-6.571	0.215	0.98	15	*	35.2
20	-7.120	0.207	0.98	13	*	39.2
10	-13.432	0.297	0.98	12	*	48.6
1	-20.434	0.341	0.91	6	*	62.9
5	-15.123	0.265	0.88	5	*	61.1
9	-17.806	0.315	0.96	7	*	59.7
21	-15.846	0.305	0.96	8	*	55.2
15	-14.008	0.274	0.97	9	*	54.8
13	-12.483	0.280	0.97	12	*	48.1
4	-7.803	0.152	0.64	5	n.s.	57.9
8	-15.279	0.270	0.89	7	*	60.3
14	-15.330	0.283	0.93	7	*	57.7
24	-15.696	0.291	0.92	8	*	57.4
18	-14.037	0.273	0.95	9	*	55.1

*significant at the 5% level

Table 2. The linear regression formulae for circulus number (Y) on fish length in mm (X), the correlation coefficient (r), and the estimated length of the fish when the first circulus is formed in each of the 25 body positions for coho salmon fry.

Body pos.	a	b	r	n	Sig.	length at first circulus
2	-8.432	0.214	0.96	16	*	44.1
6	-6.391	0.202	0.94	16	*	36.6
11	-8.135	0.234	0.96	22	*	39.0
P	-8.696	0.248	0.97	22	*	39.1
22	-8.352	0.241	0.97	22	*	38.8
16	-7.775	0.227	0.96	22	*	38.6
19	-6.766	0.195	0.96	22	*	39.8
3	-7.859	0.217	0.94	16	*	40.8
7	-8.626	0.240	0.96	21	*	40.1
12	-8.481	0.242	0.96	21	*	39.2
23	-8.778	0.251	0.97	22	*	38.9
17	-8.050	0.234	0.96	22	*	38.7
20	-7.038	0.201	0.94	19	*	40.0
10	-8.498	0.212	0.95	16	*	44.8
1	-6.190	0.135	0.84	9	*	58.6
5	-5.056	0.118	0.78	12	*	51.3
9	-8.838	0.189	0.93	16	*	49.6
21	-9.743	0.215	0.95	16	*	50.0
15	-8.547	0.195	0.95	16	*	48.9
13	-8.739	0.217	0.92	16	*	44.9
4	-4.269	0.108	0.70	9	*	48.9
8	-11.816	0.231	0.95	12	*	55.1
14	-8.395	0.175	0.87	13	*	53.7
24	-7.849	0.168	0.94	15	*	52.7
18	-8.577	0.188	0.96	15	*	50.9

*significant at the 5% level

Table 3. The linear regression formulae for circulus number (Y) on fish length in mm (X), the correlation coefficient (r), and the estimated length of the fish when the first circulus is formed in each of the 25 body positions for chum salmon fry.

Body pos.	a	b	r	n	Sig.	length at first circulus
2	-7.402	0.178	0.92	16	*	47.2
6	-8.113	0.196	0.93	16	*	46.5
11	-8.334	0.212	0.93	16	*	44.0
P	-8.443	0.223	0.93	16	*	42.3
22	-8.828	0.233	0.94	16	*	42.2
16	-8.462	0.227	0.94	16	*	41.7
19	-7.536	0.204	0.93	16	*	41.8
3	-6.859	0.176	0.86	12	*	44.6
7	-8.474	0.205	0.95	16	*	46.2
12	-8.573	0.217	0.93	16	*	44.1
23	-8.233	0.218	0.94	16	*	42.4
17	-8.456	0.228	0.94	16	*	41.5
20	-7.185	0.195	0.93	16	*	42.0
10	-7.324	0.177	0.89	12	*	47.0
1	-	-	-	0	-	-
5	-	-	-	1	-	-
9	-7.560	0.136	0.63	8	-	62.9
21	-8.271	0.153	0.79	9	*	60.6
15	-5.373	0.119	0.81	16	*	53.6
13	-7.673	0.183	0.91	16	*	47.4
4	-	-	-	0	-	-
8	-	-	-	1	n.s.	-
14	-7.792	0.154	0.95	7	*	57.1
24	-6.586	0.126	0.64	8	n.s.	60.2
18	-7.582	0.166	0.89	12	*	51.7

*significant at the 5% level

Table 4. The mean number of circuli formed on scales when sampled on the same date and of the same mean length.

Body pos.	Eight chinook fry Mean length of 59.2 mm	Six coho fry Mean length of 59.3 mm	Four chum fry Mean length of 59.5 mm
	X No. circuli	X No. circuli	X No. circuli
2	4.7	5.0	3.0
6	5.2	6.2	3.5
11	5.6	6.8	4.5
P	6.1	6.8	4.8
22	6.2	6.7	5.0
16	6.1	6.5	5.0
19	5.2	5.5	5.7
3	5.1	5.5	3.8
7	5.2	6.5	4.0
12	5.9	7.2	4.3
23	6.2	7.0	4.8
17	6.0	6.5	5.5
20	5.5	5.7	4.5
10	4.4	4.3	5.0
1	0.2	0.3	0.0
5	0.0	2.0	0.0
9	1.1	3.5	0.5
21	2.1	4.0	0.0
15	2.0	3.8	1.0
13	4.2	5.6	2.8
4	0.0	1.8	0.0
8	0.2	2.2	0.0
14	0.7	2.6	0.0
24	1.4	3.4	0.0
18	2.5	3.3	2.0

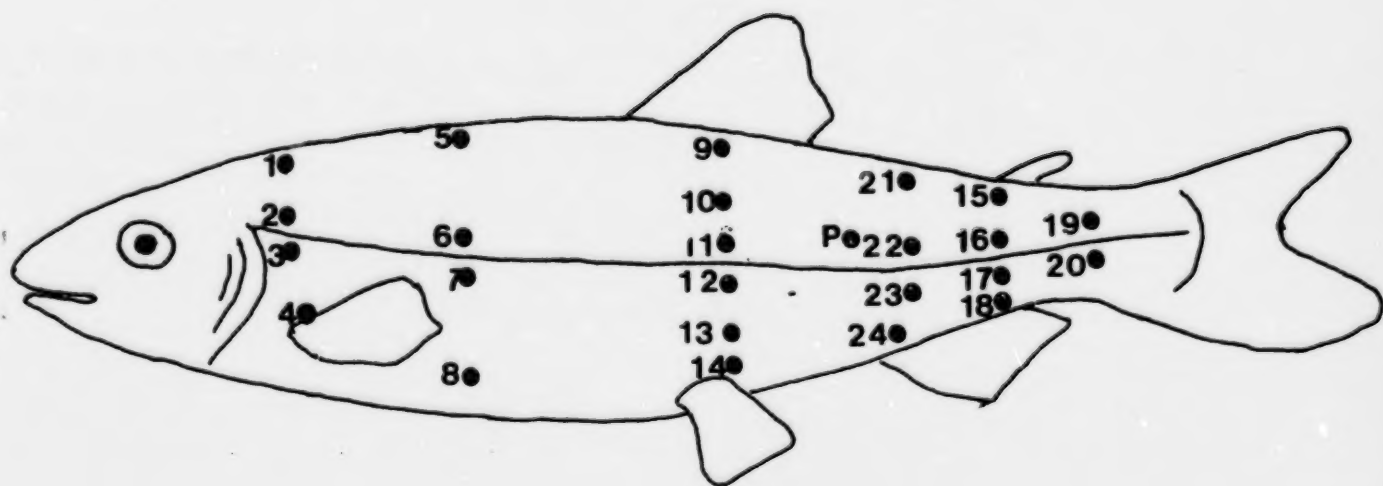
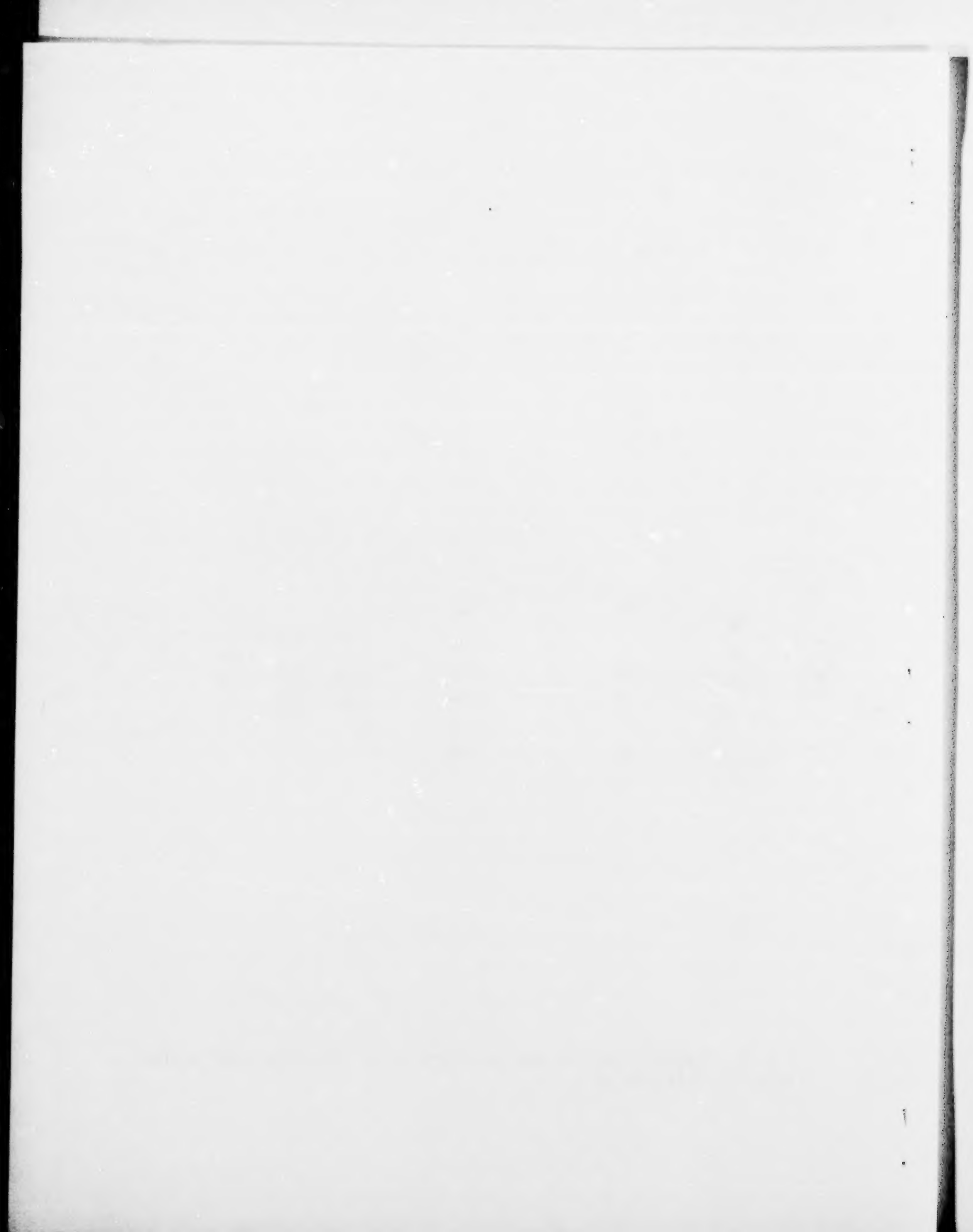
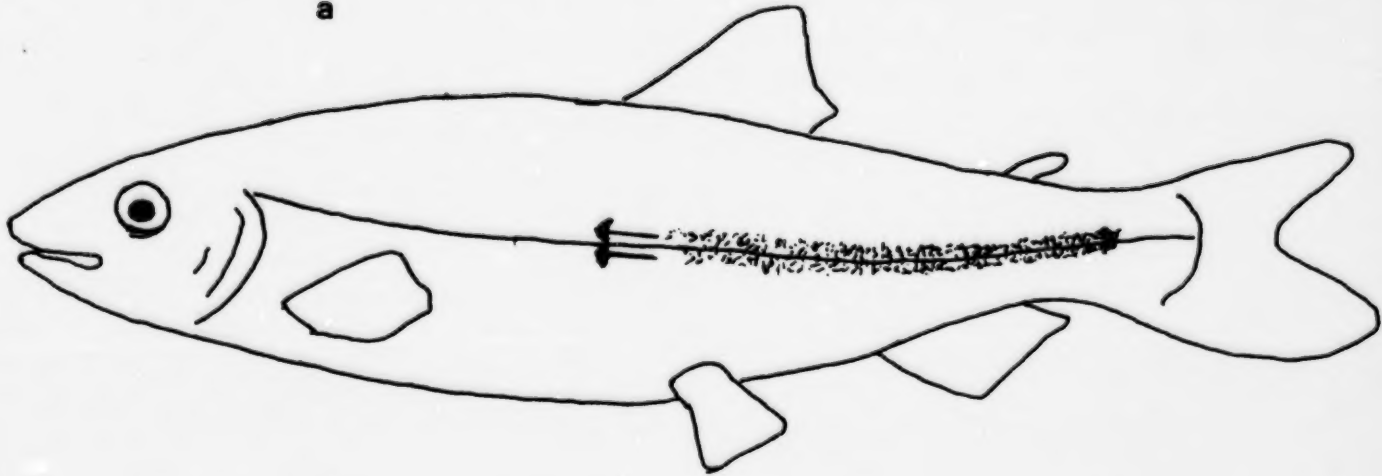


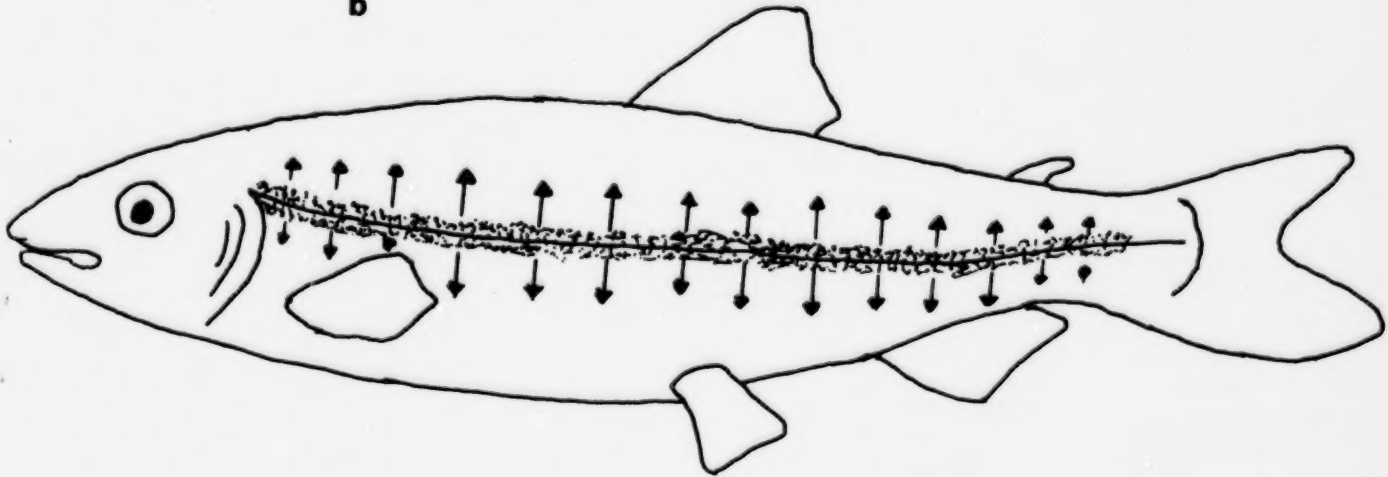
Fig. 1. Diagram shows the body positions on the fish from which scales were routinely sampled.



a



b



c

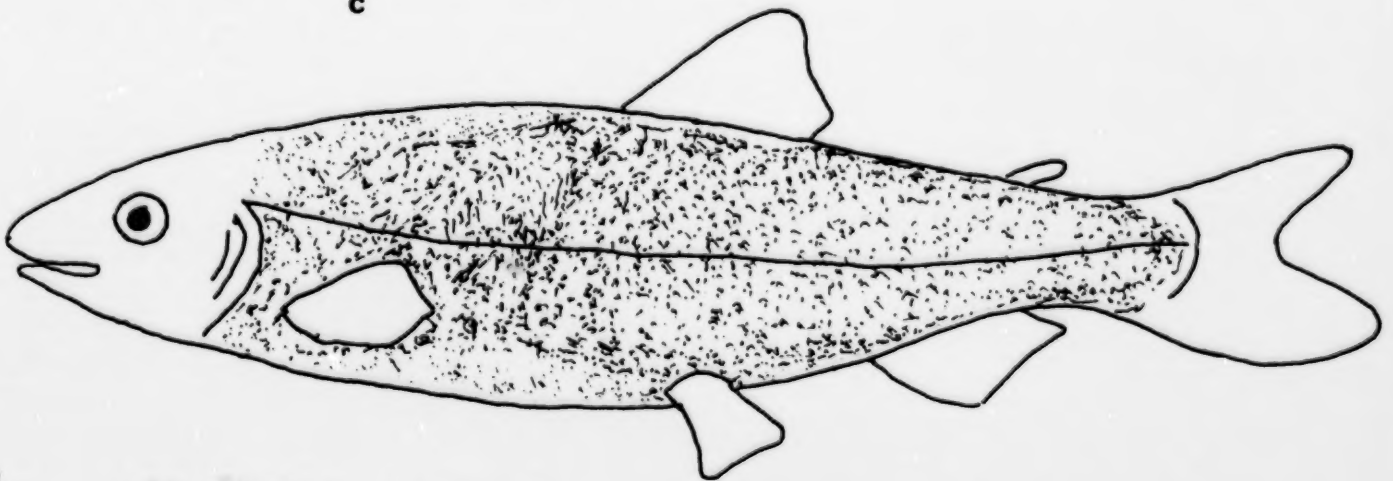


Fig. 2a, b, c. Diagram shows the progression of scale formation on the sides of chinook salmon fry.

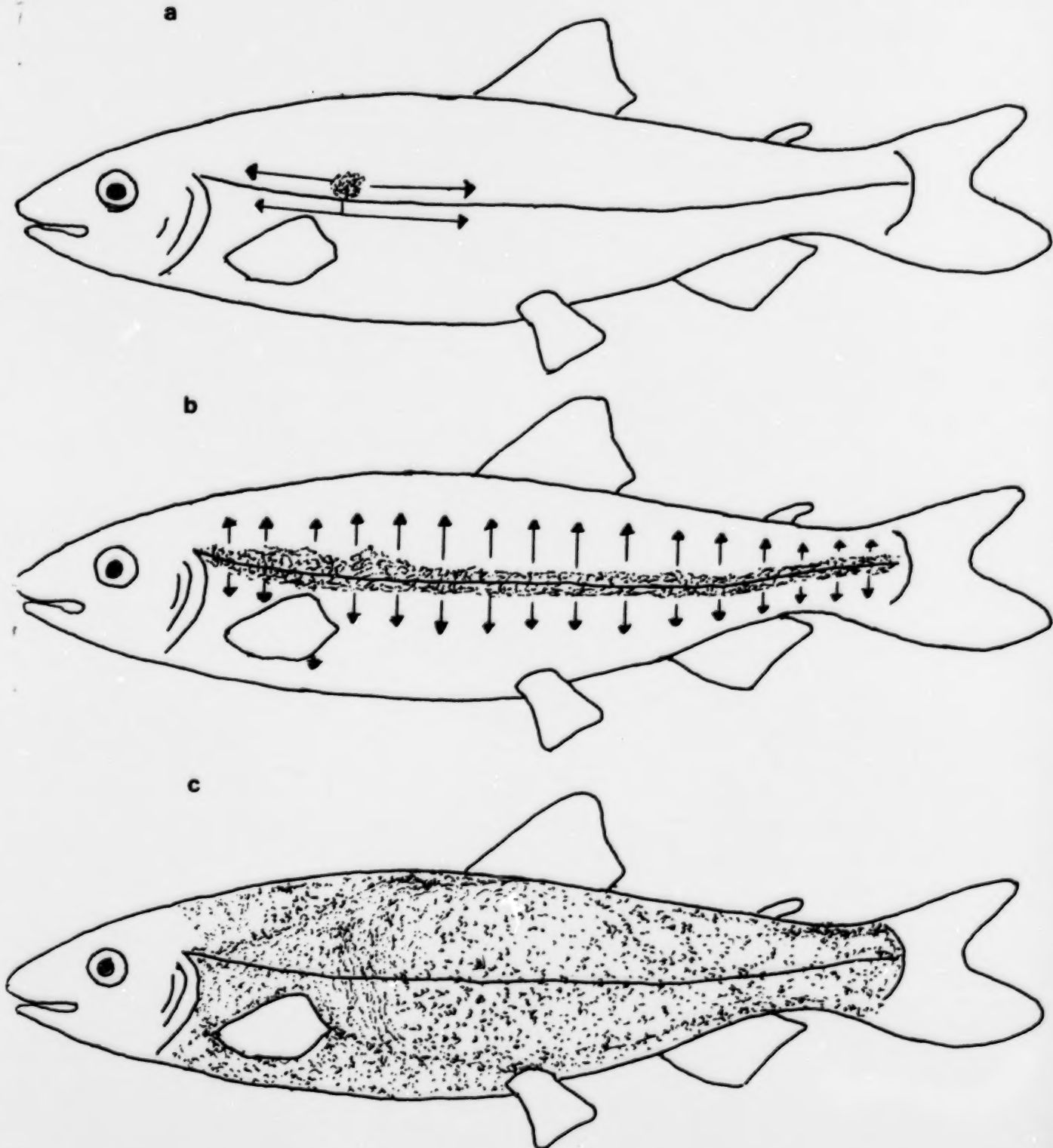


Fig. 3a, b, c. Diagram shows the progression of scale formation on the sides of coho salmon fry.



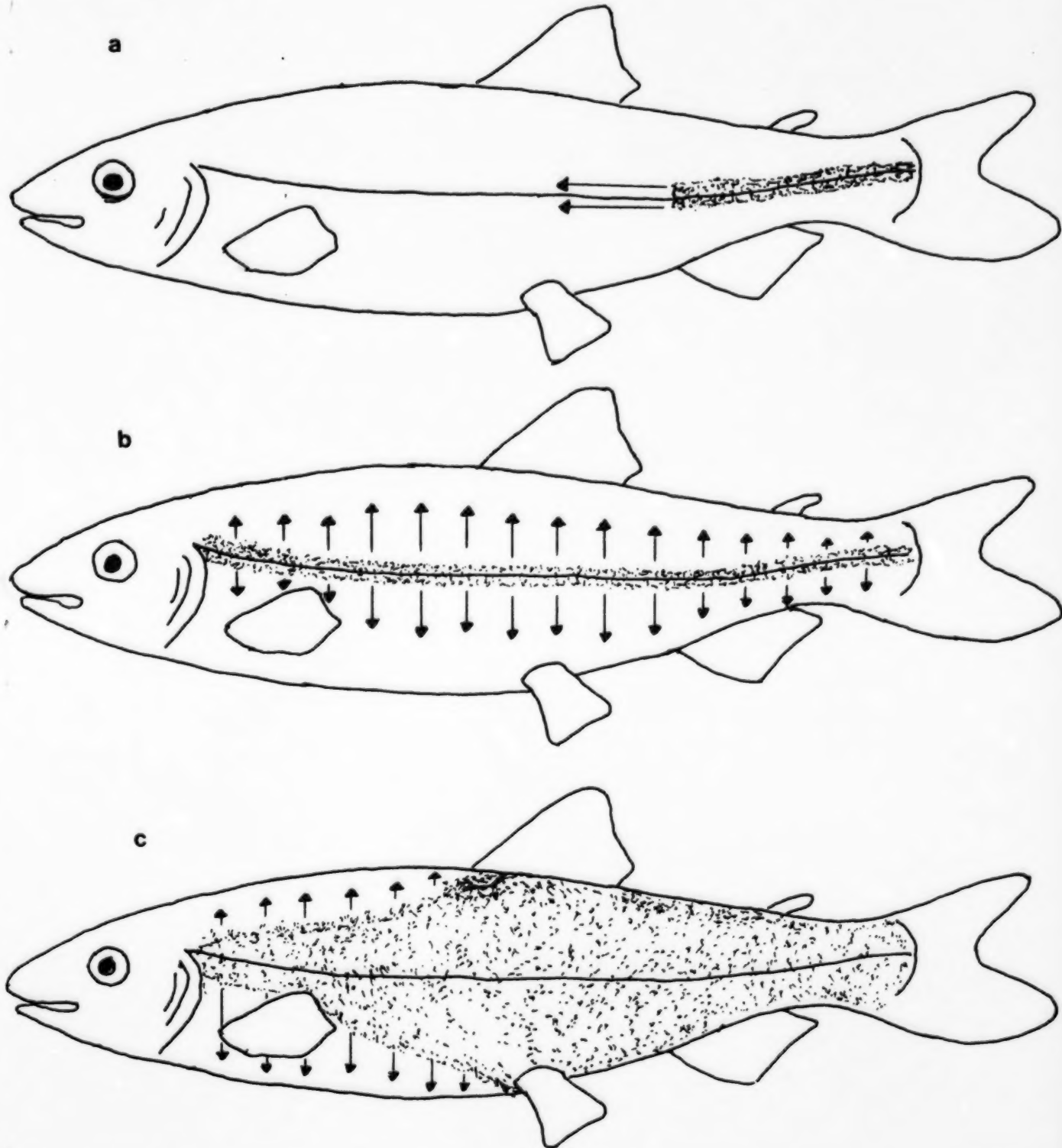


Fig. 4a, b, c. Diagram shows the progression of scale formation on the sides of chum salmon fry.